

# PATENT ABSTRACTS OF JAPAN

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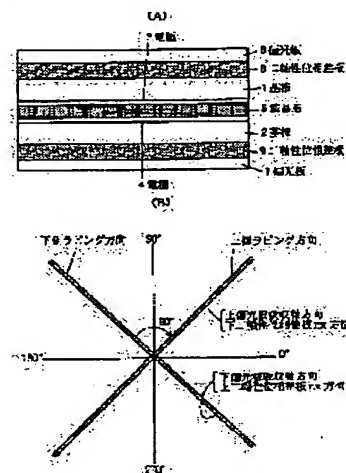
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## (54) LIQUID CRYSTAL DISPLAY DEVICE

### (57)Abstract:

**PROBLEM TO BE SOLVED:** To provide a phase difference plate which can improve the field angle dependency of a liquid crystal layer and a polarizing plate included in the liquid crystal display device at the same time.

**SOLUTION:** The liquid crystal display device is assembled by using a couple of upper and lower substrates 1 and 2 which are joined together across a specific gap. The substrates 1 and 2 have electrodes 3 and 4 formed respectively, a liquid crystal layer 5 is held in the gap between both the substrates 1 and 2, and the optical characteristics vary with the voltage applied to the electrodes 3 and 4. Polarizing plates 6 and 7 are arranged while joined to the substrates 1 and 2. Phase difference plates 8 and 9 are interposed between the upper and lower polarizing plates 6 and 7 and liquid crystal layer 5 and compensate the field angle dependency of optical characteristics of the liquid crystal layer 5. The liquid crystal layer 5 is formed of a liquid crystal material with negative dielectric anisotropy subjected to orientation control along the thickness perpendicular to the substrates 1 and 2. The phase difference plates 8 and 9 are formed of biaxial birefringent materials which have optical axes in the surface direction parallel to the substrates 1 and 2 and optical axes along the thickness crossing them at right angles, and the field angle dependency of the liquid crystal layer 5 and the field angle dependency of the polarizing plates 6 and 7 are compensated at the same time.



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**CLAIMS**

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[Claim(s)]

[Claim 1] The substrate of a pair with which it joined mutually through the predetermined gap, and the electrode was formed in one side at least, The liquid crystal layer from which an optical property changes according to the electrical potential difference which is held in this gap and impressed to this electrode, It is the liquid crystal display equipped with the polarizing plate joined to each substrate, and at least one phase contrast plate with which it intervenes between each polarizing plate and this liquid crystal layer, and the viewing-angle dependency of the optical property is compensated. Said liquid crystal layer is a liquid crystal display characterized by consisting of a liquid crystal ingredient which has the negative dielectric anisotropy by which orientation control was carried out in the thickness direction perpendicular to this substrate, and said phase contrast plate consisting of an optically biaxial birefringence ingredient which has the optical axis of the thickness direction which intersects perpendicularly with the optical axis of the direction of a field parallel to this substrate, and this.

[Claim 2] Said birefringence ingredient is a liquid crystal display according to claim 1 characterized by lying at right angles to the absorption shaft of the polarizing plate with which bearing of  $n_x$  adjoins, when the refractive index of bearing which serves as max in the direction of a field is set to  $n_x$ , the refractive index of bearing which intersects perpendicularly with this is set to  $n_y$  and the refractive index of the thickness direction is set to  $n_z$ .

[Claim 3] Said birefringence ingredient is a liquid crystal display according to claim 2 characterized by filling relation ( $0 < (n_x - n_y)$  and  $df < 150\text{nm}$ ) if thickness of a phase contrast plate is set to  $df$ .

[Claim 4] Said birefringence ingredient is a liquid crystal display according to claim 3 characterized by setting up the value of  $\{(n_x + n_y) / 2 - n_z\}$  and  $df$  according to the value of  $\Delta n - \Delta LC$ , when thickness of a phase contrast plate is set to  $df$ , thickness of a liquid crystal layer is set to  $dLC$  and the refractive-index anisotropy of the liquid crystal layer which met in the thickness direction is set to  $\Delta n$ .

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**DETAILED DESCRIPTION**

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to a liquid crystal display. It is related with the phase contrast plate used in more detail in order to compensate the viewing-angle dependency of liquid crystal.

[0002]

[Description of the Prior Art] Drawing 6 is the mimetic diagram showing an example of the conventional liquid crystal display. Left-hand side (ON) shows an electrical-potential-difference impression condition, and right-hand side (OFF) shows electrical-potential-difference the condition of not impressing. The polarization shaft A of the upper polarizing plate 101 and the polarization shaft B of the lower polarizing plate 102 lie at right angles mutually. In the state of no electrical-potential-difference impressing, orientation control of the liquid crystal 205 is perpendicularly carried out with the up-and-down orientation film 203,204. Liquid crystal 205 uses as a principal component the pneumatic liquid crystal which has a negative dielectric anisotropy, and the chiral ingredient is added by this. If an electrical potential difference is impressed, liquid crystal 205 will shift to a level orientation condition from a perpendicular orientation condition. Consequently, 90 degrees of liquid crystal 205 serve as distorted twist alignment. In this condition, 90-degree rotatory polarization of the linearly polarized light component of the incident light which passed the upper polarizing plate 201 is carried out with the liquid crystal molecule 205 by which twist orientation was carried out, and the lower polarizing plate 202 is passed. Therefore, a white display is obtained in the state of electrical-potential-difference impression. On the other hand, since liquid crystal 205 is carrying out perpendicular orientation in the state of no electrical-potential-difference impressing, there is no rotatory power. Therefore, the linearly polarized light component of incident light is intercepted with the lower polarizing plate 202, and serves as a black display. It has been the description that the display using the pneumatic liquid crystal which perpendicular orientation control is carried out and has a negative dielectric anisotropy has the good contrast of a front view angle. However, when it observed from across, the fall of contrast became remarkable and had become a problem.

[0003]

[Problem(s) to be Solved by the Invention] As a means to solve the viewing-angle dependency of a liquid crystal display, the approach using a negative optically uniaxial phase contrast plate is learned. (A) of drawing 7 expresses typically the polarization condition when light carries out vertical incidence to liquid crystal cell CE. In addition, the x axis and the y-axis which intersect perpendicularly mutually along the direction of a field of liquid crystal cell CE are set up on account of explanation, and the z-axis is set up in the thickness direction of liquid crystal cell CE. When incidence is carried out at right angles to the polarizing plate A in which the natural light L0 has the polarization shaft PA, the light which passed the polarizing plate A turns into the linearly polarized light L1. LC shows roughly the array condition of the liquid crystal in electrical-potential-difference the condition of not impressing, with one liquid crystal molecule model among drawing. Along with the z-axis, perpendicular orientation of the liquid crystal molecule LC is carried out to the appearance mentioned above. In addition, liquid crystal has a forward optical anisotropy along with the z-axis. Since the difference of a refractive index does not arise in xy side perpendicular to the course PS of light when the molecule major axis of the liquid crystal molecule LC in liquid crystal cell CE is parallel to the course PS of light, phase contrast does not arise between Tsunemitsu who spreads the inside of liquid crystal cell CE, and abnormality light, but the linearly polarized light L1 will be spread with the linearly polarized light, if liquid crystal cell CE is penetrated. If the polarization shaft PB of a polarizing plate B is set up so that it may intersect perpendicularly with the polarization shaft PA of a polarizing plate A (this established state may be hereafter called a cross Nicol's prism), the light L2 which passed liquid crystal cell CE cannot penetrate a polarizing plate B, but will serve as a black display (dark condition).

[0004] (B) shows the polarization condition of light when light L0 carries out incidence to liquid crystal cell CE aslant. When the natural light L0 carries out incidence aslant, the light L1 which passed the

polarizing plate A turns into the linearly polarized light mostly. However, it becomes elliptically polarized light a little with the property of a polarizing plate A in fact. Since the molecule major axis of the liquid crystal molecule LC in liquid crystal cell CE accomplishes Course PS and the include angle of light, the difference of a refractive index arises in a field perpendicular to the course PS of light, the light L2 which penetrated liquid crystal cell CE will turn into elliptically polarized light, a polarizing plate B will be reached, and a part of light will penetrate a polarizing plate B. Transparency of the light in such method incidence of slanting causes the fall of the contrast of a liquid crystal display, and is not desirable.

[0005] In order to prevent the fall of the contrast in such method incidence of slanting and to improve a viewing-angle property, as shown in (C), the negative optically uniaxial phase contrast plate RF with which the optical axis was suitable in the direction of a normal of liquid crystal cell CE (z-axis) between the polarizing plate B and liquid crystal cell CE is arranged. This phase contrast plate RF is a birefringence ingredient in which such large phase contrast that the include angle light carries out [ an include angle ] incidence to an optical axis becomes large is shown. In the liquid crystal display of such a configuration, elliptically polarized light is changed into the original linearly polarized light, and the light L2 which carried out method incidence of slanting, penetrated liquid crystal cell CE, and turned into elliptically polarized light is completely intercepted with a polarizing plate B by the phase delayed action when penetrating the phase contrast plate RF. The optically uniaxial phase contrast plate RF has a negative refractive-index anisotropy, and its thickness direction refractive index is small to the direction refractive index of a field. On the other hand, liquid crystal has a forward 1 shaft optical anisotropy, and its thickness direction refractive index is large to the direction refractive index of a field. The viewing-angle dependency of liquid crystal is compensated with setting up equally to the refractive-index difference of liquid crystal, and the product of thickness the refractive-index difference of a phase contrast plate, and the product of thickness. However, the compensation function was not enough when it was seen as the whole display, since the conventional phase contrast plate was not taken into consideration to the viewing-angle property of a polarizing plate.

[0006]

[Means for Solving the Problem] The following means were provided in order to solve the technical problem of a Prior art mentioned above. Namely, the substrate of a pair with which the liquid crystal display of each other concerning this invention was joined through the predetermined gap as a fundamental configuration, and the electrode was formed in one side at least, It has the liquid crystal layer from which an optical property changes according to the electrical potential difference which was held in this gap and impressed to this electrode, the polarizing plate joined to each substrate, and at least one phase contrast plate with which it intervenes between this polarizing plate and this liquid crystal layer, and the viewing-angle dependency of the optical property is compensated. Said liquid crystal layer consists of a liquid crystal ingredient which has the negative dielectric anisotropy by which orientation control was carried out in the thickness direction perpendicular to this substrate. Said phase contrast plate consists of an optically biaxial birefringence ingredient which has the optical axis of the thickness direction which intersects perpendicularly with the optical axis of the direction of a field parallel to this substrate, and this as a description matter. Preferably, if said birefringence ingredient sets to  $n_x$  the refractive index of bearing which serves as max in the direction of a field, and sets to  $n_y$  the refractive index of bearing which intersects perpendicularly with this and the refractive index of the thickness direction is set to  $n_z$ , it lies at right angles to the absorption shaft of the polarizing plate with which bearing of  $n_x$  adjoins. Moreover, preferably, said birefringence ingredient will fill relation ( $0 < (n_x - n_y)$  and  $df < 150\text{nm}$ ), if thickness of a phase contrast plate is set to  $df$ . Furthermore, if said birefringence ingredient sets thickness of a phase contrast plate to  $df$ , thickness of a liquid crystal layer is set to  $d_{LC}$  and the refractive-index anisotropy of the liquid crystal layer which met in the thickness direction is set to  $\Delta n$ , the value of  $\{(n_x + n_y) / 2 - n_z\}$  and  $df$  is set up according to the value of  $\Delta n - d_{LC}$ .

[0007] According to this invention, the phase contrast plate is constituted using an optically biaxial birefringence ingredient, and it has the optical axis of the thickness direction which intersects

perpendicularly with the optical axis of the direction of a field parallel to a substrate, and this. The viewing-angle dependency of the liquid crystal layer which has form birefringence in the thickness direction is compensated by the form birefringence of the thickness direction of a phase contrast plate. On the other hand, about the viewing-angle dependency of a polarizing plate, it compensates using the form birefringence of the direction of a field of a phase contrast plate. That is, the oscillating direction of incident light is doubled with the absorption shaft of a polarizing plate using the birefringence of the direction of a field of a phase contrast plate. By the above configuration, a basis phase differential plate becomes possible [ compensating coincidence for a liquid crystal layer and the viewing-angle dependency of a polarizing plate ], and can improve notably the viewing-angle property of the whole liquid crystal display.

[0008]

[Embodiment of the Invention] With reference to a drawing, the gestalt of operation of this invention is explained to a detail below. As shown in (A) of drawing 1 , this liquid crystal display is assembled using the substrates 1 and 2 of a pair each other joined through the predetermined gap. Each substrates 1 and 2 consist of glass etc. The electrode 3 is formed in the internal surface of the upper substrate 1, and the electrode 4 is formed also in the internal surface of the lower substrate 2. The liquid crystal layer 5 is held in the gap of both the substrates 1 and 2. An optical property changes according to the electrical potential difference impressed to the up-and-down electrodes 3 and 4, and the liquid crystal layer 5 controls the permeability of incident light. It joins to the upper substrate 1 and the upper polarizing plate 6 is arranged. Moreover, it joins to the lower substrate 2 and the lower polarizing plate 7 is arranged. Furthermore, the upper phase contrast plate 8 intervenes between the upper polarizing plate 6 and the liquid crystal layer 5. Similarly, another phase contrast plate 9 intervenes between the lower polarizing plate 7 and the liquid crystal layer 5. With this operation gestalt, although the phase contrast plates 8 and 9 of two upper and lower sides are used, this invention is not restricted to this and should just use at least one phase contrast plate.

[0009] The liquid crystal layer 5 consists of an ingredient which has the negative dielectric anisotropy by which orientation control was carried out in the thickness direction perpendicular to the up-and-down substrates 1 and 2, and presents behavior as shown in drawing 6 according to electrical-potential-difference impression. That is, the liquid crystal layer 5 makes a subject the pneumatic liquid crystal which has a negative dielectric anisotropy and a negative forward refractive-index anisotropy, and adds a chiral ingredient to this. In the electrical-potential-difference condition of not impressing, perpendicular orientation of the pneumatic liquid crystal is carried out to substrates 1 and 2. In the state of electrical-potential-difference impression, it shifts to level orientation, and becomes 90-degree torsion orientation under the effect of the added chiral ingredient. In addition, in case a pneumatic liquid crystal molecule shifts to level orientation from perpendicular orientation, in order to regulate inclination bearing, as for the internal surface of the up-and-down substrates 1 and 2, rubbing processing is performed beforehand. It may replace with rubbing processing and other orientation control approaches may be adopted. The pre tilt angle of about 5 degrees is given to the pneumatic liquid crystal molecule along the direction of rubbing by this rubbing processing. The pre tilt angle means the tilt angle of the major axis of the liquid crystal molecule to the normal of a substrate.

[0010] As a description matter of this invention, the Gentlemen phase differential plates 8 and 9 consist of an optically biaxial birefringence ingredient which has the optical axis of the thickness direction which intersects perpendicularly with the optical axis of the direction of a field parallel to substrates 1 and 2, and this. Hereafter, with reference to (B), the relation between the optical axis of a phase contrast plate, the direction of rubbing, and the absorption shaft of a polarizing plate is explained. (B) is the top view which looked at the screen of this liquid crystal display from the top, and has taken bearing (0 degree and 180 degrees) in the direction of right and left of a screen. If a birefringence ingredient sets to  $n_x$  the refractive index of bearing which serves as max in the direction of a field, and sets to  $n_y$  the refractive index of bearing which intersects perpendicularly with this and the refractive index of the thickness

direction is set to  $n_z$ , it lies at right angles to the absorption shaft of the polarizing plate with which bearing of  $n_x$  adjoins. Specifically, the absorption shaft orientations of the top polarizing plate 6 and  $n_x$  bearing of the upper optically biaxial phase contrast plate 8 lie at right angles mutually. Similarly, the absorption shaft orientations of the lower polarizing plate 7 and  $n_x$  bearing of the lower optically biaxial phase contrast plate 9 lie at right angles mutually. Thus, it becomes possible to double with the absorption shaft of a polarizing plate the oscillating direction of the light which carried out incidence from across by setting up. In addition, the direction of rubbing of the top substrate 1 is in agreement with the absorption shaft orientations of the upper polarizing plate 6. Moreover, the direction of rubbing of the lower substrate 2 and the absorption shaft orientations of the lower polarizing plate 7 are also mutually in agreement. And the absorption shaft of the top polarizing plate 6 and the absorption shaft of the bottom polarizing plate 7 lie at right angles mutually, and serve as the so-called cross Nicol's prism arrangement. In addition, in order to improve the viewing-angle dependency of a polarizing plate using the form birefringence of the direction of a field of a phase contrast plate, when thickness of a phase contrast plate is set to  $df$ , it is desirable [ said birefringence ingredient ] to fill relation ( $0 < (n_x - n_y)$  and  $df < 150\text{nm}$ ). This is as a result of simulation, and an optimum value is about  $60\text{nm}$ .

[0011] The phase contrast plates 8 and 9 concerning this invention have compensated coincidence also for the viewing-angle dependency of the liquid crystal layer 5 while compensating the viewing-angle dependency of polarizing plates 6 and 7. That is, he is trying to negate the birefringence of the thickness direction of the liquid crystal layer 5 using the birefringence of the thickness direction of the Gentlemen phase differential plates 8 and 9. In this case, if said birefringence ingredient sets thickness of a phase contrast plate to  $df$ , thickness of a liquid crystal layer is set to  $d_{LC}$  and the refractive-index anisotropy of the liquid crystal layer which met in the thickness direction is set to  $\Delta n$ , the value of  $\{(n_x + n_y) / 2 - n_z\}$  and  $df$  will be set up according to the value of  $\Delta n - d_{LC}$ .

[0012] A concrete numeric value is hereafter given to each parameter mentioned above, and an example is explained. The value of  $\Delta n - d_{LC}$  of the liquid crystal layer 5 is  $420\text{nm}$ . On the other hand,  $n_x$  of the optically biaxial Gentlemen phase differential plates 8 and 9 is  $1.58839$ ,  $n_y$  is  $1.58797$ , and  $n_z$  is  $1.58705$ . Thickness  $df$  of the Gentlemen phase differential plates 8 and 9 is  $142\text{micrometers}$ . Furthermore,  $n_x$  of the protective coat contained in each up-and-down polarizing plates 6 and 7 is  $1.59082$ , similarly  $n_y$  is  $1.59082$ , and  $n_z$  is  $1.5902$ . The thickness of this protective coat is  $80\text{micrometers}$ . The above value of  $\Delta n$ ,  $n_x$ ,  $n_y$ , and  $n_z$  is measured to incident light with a wavelength of  $550\text{nm}$ . It will be set to  $\{(n_x + n_y) / 2 - n_z\}$  and  $df = 160\text{nm}$  if its attention is paid to the Gentlemen phase differential plates 8 and 9. This value expresses the retardation in the thickness direction of one phase contrast plate. Moreover, the retardation of the thickness direction of the protective coat contained in each polarizing plates 6 and 7 is  $x(1.59082 - 1.5902)80\text{micrometer} = 50\text{nm}$ . In this example, two polarizing plates 6 and 7 are also used by the upper and lower sides using two phase contrast plates 8 and 9 up and down. Therefore, total of the retardation of the thickness direction mentioned above is  $160\text{nm} \times 2 + 50\text{nm} \times 2 = 420\text{nm}$ . This value is in agreement with the value of  $420\text{nm}$  of retardation  $\Delta n - d_{LC}$  of the liquid crystal layer 5. Thereby, it becomes possible to negate the form birefringence of the liquid crystal layer 5 with the phase contrast plates 8 and 9. What is necessary is just to make it in agreement [ both sum total ] with the retardation of the liquid crystal layer 5 in general in consideration of the value of the retardation of the protective coat contained in polarizing plates 6 and 7, in case the value of the retardation of the Gentlemen phase differential plates 8 and 9 is set up. On the other hand, in the case of this example  $(n_x - n_y)$ , the value of the retardation of the direction of a field of the Gentlemen phase differential plates 8 and 9 is set as  $-df = 60\text{nm}$ . What is necessary is generally, just to set up appropriately the retardation of the direction of a field of the Gentlemen phase differential plates 8 and 9 by less than  $150\text{nm}$ . When it exceeds  $150\text{nm}$ , the birefringence of the direction of a field of a phase contrast plate comes to be too strong, and there is a possibility of having a bad influence on the viewing-angle property of a liquid crystal display conversely.

[0013] Drawing 2 is a graph which shows the viewing-angle property of a liquid crystal display. Field bearing of the screen of a display was made rightward into  $0$  degree, and  $180$  degrees is decided on

leftward. The contrast curve, such as a case where changed bearing from 0 degree to 360 degrees, and it measures from across to the normal of a screen, is expressed. Contrast curves, such as the inside, support the contrast ratio 50, and the outside contrast curve supports the contrast ratio 10. In addition, a contrast ratio takes a ratio with permeability in case permeability and applied voltage in case applied voltage is OFF are ON. (A) is as a result of [ at the time of using an optically biaxial phase contrast plate according to this invention ] measurement, and (B) is as a result of [ of having used the conventional optically uniaxial phase contrast plate ] measurement. If both are compared, compared with the former, the viewing-angle property of a liquid crystal display is sharply improved by this invention so that clearly. That is, it is possible by using an optically biaxial phase contrast plate to improve not only the viewing-angle dependency of a liquid crystal layer but the viewing-angle dependency of a polarizing plate to coincidence.

[0014] Drawing 3 is the mimetic diagram showing other operation gestalten of the liquid crystal display concerning this invention. It is the same as that of the previous operation gestalt shown in drawing 1 fundamentally, and a corresponding reference number is given to a corresponding part, and an understanding is made easy. A different point is in an electrical-potential-difference impression condition with this operation gestalt, and 5m of liquid crystal molecules is not carrying out torsion orientation but carrying out level orientation. For this reason, the direction of rubbing of the top substrate 1 and the direction of rubbing of the bottom substrate 2 are parallel mutually. Moreover, the chiral ingredient is not added by liquid crystal. As shown in (A), while 5m of liquid crystal molecules carries out perpendicular orientation at the time of no impressing [ of a signal level ], it shifts to level orientation at the time of impression of a signal level, and incident light is modulated. The upper polarizing plate 6 and the lower polarizing plate 7 are arranged at the cross Nicol's prism. As shown in the left-hand side of (A), in the state of no electrical-potential-difference impressing, perpendicular orientation of the 5m of the liquid crystal molecules is carried out, and they carry out outgoing radiation of the incidence polarization as it is as outgoing radiation polarization, without receiving a modulation at all. Therefore, in the state of a cross Nicol's prism, a display presents black at the time (at the time of OFF) of no electrical-potential-difference impressing. On the other hand, as shown in the right-hand side of (A), in the time of electrical-potential-difference impression, 5m of liquid crystal molecules shifts to level orientation along bearing parallel to space. The orientation condition of 5m of this liquid crystal molecule presents an optically uniaxial birefringence, the 90-degree polarization direction rotates by 5m of liquid crystal molecules which carried out level orientation, and the incidence polarization which passed the polarizing plate 6 turns into outgoing radiation polarization. For this reason, passage of outgoing radiation polarization will be attained in the polarizing plate 7 of the bottom which carried out cross Nicol's prism arrangement, and a display will be white in the state of electrical-potential-difference impression (ON condition). If it puts in another way, the liquid crystal which carried out level orientation will be setting up the thickness appropriately, and will function as a half-wave plate. If an electrical potential difference is impressed to a liquid crystal cell, liquid crystal molecular arrangement will change and, as a result, the rate of a birefringence in a cel will change with the dielectric anisotropies of liquid crystal. If a liquid crystal cell is placed into two polarizing plates 6 and 7, change of this rate of a birefringence will appear as change of light transmittance, and will call this the ECB effectiveness. The method which displays using this effectiveness is called ECB mode, and it is classified into a DAP mold, a homogeneous mold, and a HAN mold according to the difference in initial orientation. This inner DAP mold is used especially for this operation gestalt. That is, the molecule shaft (liquid crystal director) of 5m of liquid crystal molecules calls a DAP mold the thing using a perpendicular homeotropic orientation cel to a substrate, and a dielectric anisotropy uses a negative pneumatic liquid crystal. In this DAP mold, in order to make contrast of a display high, it is important at the time of electrical-potential-difference impression to arrange the inclination of a molecule with an one direction, and it is made to take the initial orientation (pre tilt) to which the liquid crystal director inclined a little from the substrate for this reason. With this operation gestalt, this pre tilt angle is set as 5 degrees.



[0015] The Gentlemen phase differential plates 8 and 9 with which the liquid crystal cell was allotted up and down also with this operation gestalt are optically biaxial, and are the same as that of a previous operation gestalt. As shown in (B), the absorption shaft orientations of the upper polarizing plate 6 and nx bearing of the upper optically biaxial phase contrast plate 8 lie at right angles mutually. Moreover, nx bearing of the optically biaxial phase contrast plate 9 of the absorption shaft orientations of the bottom polarizing plate 7 and the bottom also lies at right angles mutually. The absorption shaft orientations of the upper polarizing plate 6 and the absorption shaft orientations of the bottom polarizing plate 7 lie at right angles mutually, and serve as a cross Nicol's prism at the appearance mentioned above. Moreover, the direction of bottom rubbing and the direction of top rubbing are mutually parallel. These directions of rubbing have accomplished the absorption shaft orientations of a polarizing plate, and the include angle of 45 degrees.

[0016] (A) of drawing 4 is a graph which shows contrast curves, such as an operation gestalt shown in drawing 3. (B) shows a contrast curve, such as a case where replaced with the optically biaxial phase contrast plate, and an optically uniaxial phase contrast plate is used, for a comparison. (A) And if (B) is compared, it will become possible by using an optically biaxial phase contrast plate also with this operation gestalt to improve the viewing-angle property as the whole liquid crystal display so that clearly.

[0017] The improvement technique of an angle of visibility in which the form birefringence of a phase contrast plate was used is combinable with the angle-of-visibility improvement technique in which other methods were used. For example, an angle of visibility is improvable by setting to the liquid crystal display which has the pixel arranged in the shape of a matrix, and performing orientation control halved or quadrisected within each pixel. This invention is combinable with the angle-of-visibility improvement technique by such orientation split plot experiment. Moreover, it is also combinable with the angle-of-visibility improvement technique using the combination of a directive back light and an optical diffusion plate. This operation gestalt is shown in drawing 5. In addition, in this operation gestalt, a corresponding reference number is given to the operation gestalt shown in drawing 1, and a corresponding part, and an understanding is made easy. As shown in (A), this liquid crystal display consists of the panels 0, the directive back lights 20, and the optical diffusion plates 10 of a transparency mold. A panel 0 has the configuration which stuck the glass substrate of a pair mutually, and liquid crystal is enclosed with both gap. In the front face of a top substrate, the polarizing plate 6 and the optically biaxial phase contrast plate 8 are arranged. Another polarizing plate 7 also on a rear face and the optically biaxial phase contrast plate 9 of a bottom glass substrate arrange. These glass substrates have about 1.53 refractive index. The directive back light 20 is arranged at the rear-face side of a panel 0, and carries out incidence of the illumination light near in parallel to a panel 0. A back light 20 consists of the light source 21 and a prism sheet 22 in this example. The light source 21 consists of fluorescence tubing of a flat-surface mold etc., and emits an indirectional light. The prism sheet 22 makes an indirectional light emitted from the light source 21 refracted, and is mostly collimated in parallel light.

[0018] The optical diffusion plate 10 is arranged at a front-face side, and carries out diffusion outgoing radiation of the illumination light which penetrated the panel 0. The optical diffusion plate 10 consists of transparent particle 10a with which it was covered between the front face of a panel 0, and the phase contrast plate 8. The clearance between this particle 10a is filled by transparent bulking agent 10b. While particle 10a has a different refractive index from the glass substrate which constitutes the front face of a panel 0, bulking agent 10b has the refractive index near a glass substrate. For example, this particle 10a consists of a transparent micro bead, and mean particle diameter of a refractive index is 1.93 in about 30 micrometers. This is greatly different from the refractive index 1.53 of a glass substrate, and is equipped with the outstanding optical diffusibility. In addition, the board thickness of a glass substrate is about 1.1mm. On the other hand, transparent bulking agent 10b consists of resin of for example, an ultraviolet curing mold, and the refractive index is 1.55 and is almost equal to the refractive index of a glass substrate. After the transparence light which carried out outgoing radiation from the directive back



light 20 passes a panel 0, outgoing radiation of it is carried out in the form scattered about by particle 10a. Diffusion is strong and a cause angle of visibility spreads, so that the refractive index of particle 10a is large.

[0019] (B) is the typical sectional view showing an example of the panel 0 shown in (A). This panel has the flat structure which carried out the laminating of the common middle plate 113 which consists of a dielectric sheet which intervenes between a liquid crystal cell 111, a plasma cell 112, and both. The liquid crystal cell 111 is constituted using the glass substrate 114 by the side of a front face, and two or more signal electrodes 115 which consist of transparence electric conduction film are mutually formed in the inside principal plane in parallel. The glass substrate 114 is pasted up on the middle plate 113 through the predetermined gap using the spacer 116. It fills up with liquid crystal 117 in the gap. On the other hand, the plasma cell 112 is constituted using the glass substrate 118 by the side of a rear face. On the inside principal plane of a glass substrate 118, two or more plasma electrodes 119 which intersect perpendicularly with a signal electrode 115 are formed, and a pair is accomplished as an anode 120 and a cathode 121 by turns. In order to compartment each electrode pair to the internal surface of a glass substrate 118, the stripe-like septum 122 is formed. The crowning of a septum 122 is in contact with the middle plate 113. The glass substrate 118 is joined to the middle plate 113 using the frit seal 123. Among both, the plasma room 124 by which the hermetic seal was carried out is formed. This plasma room 124 constitutes the discharge channel which is divided by the septum 122 and serves as a scan unit separately. Ionizable gas is enclosed with the interior of this airtight plasma room 124. A type of gas can choose helium, neon, argons, or these mixture of gas. The discharge channel which constitutes each scan unit, and the signal electrode 115 which constitutes a drive unit lie at right angles mutually, and a matrix-like pixel is specified to the intersection.

[0020] In the panel which has the starting configuration, while switching and scanning the discharge channel to which plasma discharge is performed by line sequential, a display drive is performed by impressing a picture signal to the signal electrode 115 by the side of a liquid crystal cell 111 synchronizing with this scan. If plasma discharge occurs in a discharge channel, the interior will become anode potential at about 1 appearance, and pixel selection in every line will be performed. That is, a discharge channel functions as a sampling switch. If a picture signal is impressed to each pixel after the plasma sampling switch has flowed, a sampling is performed and lighting or putting out lights which is a pixel can be controlled. Also after a plasma sampling switch will be in non-switch-on, a picture signal is held in a pixel as it is.

[0021]

[Effect of the Invention] As explained above, according to this invention, coincidence is compensated for the viewing-angle dependency of liquid crystal, and the viewing-angle dependency of a polarizing plate using the optically biaxial birefringence ingredient which has the optical axis of the thickness direction which intersects perpendicularly with the optical axis of the direction of a field parallel to a substrate, and this. By the starting configuration, it becomes possible to improve the viewing-angle property of a liquid crystal display, and the display screen where contrast is high and where the viewing-angle range is wide can be obtained.

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[Translation done.]

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] It is the mimetic diagram showing the operation gestalt of the liquid crystal display concerning this invention.

[Drawing 2] It is the graph which shows contrast curves, such as a liquid crystal display.

[Drawing 3] It is the mimetic diagram showing other operation gestalten of the liquid crystal display concerning this invention.

[Drawing 4] It is the graph which shows contrast curves, such as a liquid crystal display.

[Drawing 5] It is the typical sectional view showing another operation gestalt of the liquid crystal display concerning this invention.

[Drawing 6] It is the mimetic diagram showing an example of the conventional liquid crystal display.

[Drawing 7] It is the mimetic diagram showing an operation of the phase contrast plate used for the conventional liquid crystal display.

[Description of Notations]

1 [ ... An electrode, 5 / ... A liquid crystal layer, 6 / ... A polarizing plate, 7 / ... A polarizing plate, 8 / ... An optically biaxial phase contrast plate, 9 / ... Optically biaxial phase contrast plate ] ... A substrate, 2 ... A substrate, 3 ... An electrode, 4

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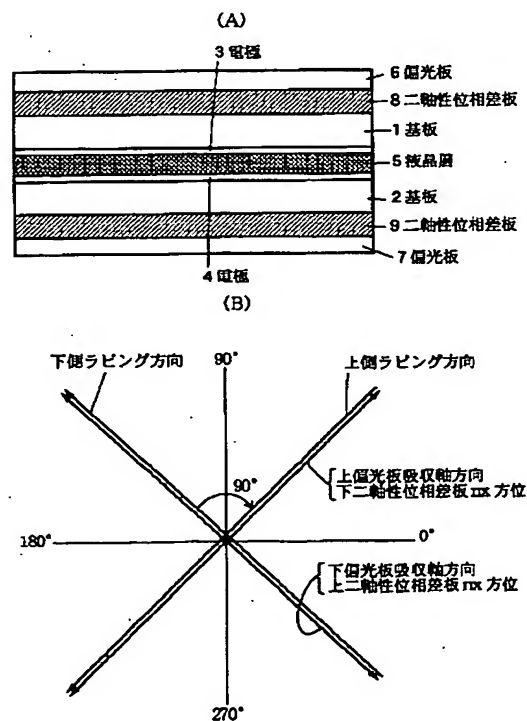
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(54)【発明の名称】 液晶表示装置

(57)【要約】

【課題】 液晶表示装置に含まれる液晶層及び偏光板の視角依存性を同時に改善可能な位相差板を提供する。

【解決手段】 液晶表示装置は所定の間隙を介して互いに接合した上下一対の基板1, 2を用いて組み立てられている。一对の基板1, 2には各々電極3, 4が形成されている。両基板1, 2の間隙には液晶層5が保持されており、電極3, 4に印加された電圧に応じて光学特性が変化する。各基板1, 2に接合して偏光板6, 7が配されている。上下の偏光板6, 7と液晶層5との間に各々位相差板8, 9が介在しており、液晶層5の光学特性の視角依存性を補償する。液晶層5は基板1, 2に垂直な厚み方向に配向制御された負の誘電異方性を有する液晶材料からなる。各位相差板8, 9は基板1, 2に平行な面方向の光軸及びこれと直交する厚み方向の光軸を有する二軸性の複屈折材料からなり、液晶層5の視角依存性と偏光板6, 7の視角依存性を同時に補償する。



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## 【特許請求の範囲】

【請求項1】 所定の間隙を介して互いに接合し且つ少くとも片側に電極が形成された一对の基板と、該間隙に保持され該電極に印加される電圧に応じて光学特性が変化する液晶層と、各基板に接合する偏光板と、各偏光板と該液晶層との間に介在しその光学特性の視角依存性を補償する少くとも一枚の位相差板とを備えた液晶表示装置であって、

前記液晶層は該基板に垂直な厚み方向に配向制御された負の誘電異方性を有する液晶材料からなり、  
前記位相差板は該基板に平行な面方向の光軸及びこれと直交する厚み方向の光軸を有する二軸性の複屈折材料からなることを特徴とする液晶表示装置。

【請求項2】 前記複屈折材料は、面方向で最大となる方位の屈折率を $n_x$ とし、これと直交する方位の屈折率を $n_y$ とし、厚み方向の屈折率を $n_z$ とすると、 $n_x$ の方位が隣接する偏光板の吸収軸と直交していることを特徴とする請求項1記載の液晶表示装置。

【請求項3】 前記複屈折材料は、位相差板の厚みを $d_f$ とすると $0 < (n_x - n_y) \cdot d_f < 150 \text{ nm}$ の関係を満たすことを特徴とする請求項2記載の液晶表示装置。

【請求項4】 前記複屈折材料は、位相差板の厚みを $d_f$ とし、液晶層の厚みを $d_{LC}$ とし、厚み方向に沿った液晶層の屈折率異方性を $\Delta n$ とすると、 $\{(n_x + n_y) / 2 - n_z\} \cdot d_f$ の値が $\Delta n \cdot d_{LC}$ の値に応じて設定されていることを特徴とする請求項3記載の液晶表示装置。

## 【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は液晶表示装置に関する。より詳しくは、液晶の視角依存性を補償する為に用いられる位相差板に関する。

【0002】

【従来の技術】図6は従来の液晶表示装置の一例を示す模式図である。左側の(ON)が電圧印加状態を示し、右側の(OFF)が電圧無印加状態を示す。上側の偏光板101の偏光軸Aと下側の偏光板102の偏光軸Bは互いに直交している。電圧無印加状態では、液晶205は上下の配向膜203、204によって垂直に配向制御されている。液晶205は負の誘電異方性を有するネマティック液晶を主成分とし、これにカイラル材料が添加されている。電圧を印加すると液晶205は垂直配向状態から水平配向状態に移行する。この結果、液晶205は90°ねじれたツイスト整列となる。この状態では、上側の偏光板201を通過した入射光の直線偏光成分が、ツイスト配向された液晶分子205により90°旋光され下側の偏光板202を通過する。従って電圧印加状態では白色表示が得られる。一方、電圧無印加状態では液晶205が垂直配向しているので旋光能がない。従

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って、入射光の直線偏光成分は下側の偏光板202によって遮断され黒色表示となる。垂直配向制御され且つ負の誘電異方性を有するネマティック液晶を用いた表示装置は、正面視角のコントラストが良いことが特徴になっている。しかし、斜め方向から観察した場合コントラストの低下が顕著となり、問題となっていた。

【0003】

【発明が解決しようとする課題】液晶表示装置の視角依存性を解決する手段として、負の一軸性位相差板を用いる方法が知られている。図7の(A)は、液晶セルCEに光が垂直入射した場合の偏光状態を模式的に表わしている。なお、説明の都合上、液晶セルCEの面方向に沿って互いに直交するx軸及びy軸を設定し、液晶セルCEの厚み方向にz軸を設定してある。自然光L0が偏光軸PAを持つ偏光板Aに垂直に入射した時、偏光板Aを通過した光は、直線偏光L1となる。図中、LCは電圧無印加状態における液晶の配列状態を概略的に一つの液晶分子モデルで示したものである。前述した様に、液晶分子LCはz軸に沿って垂直配向している。なお、液晶はz軸に沿って正の光学異方性を有する。液晶セルCE中の液晶分子LCの分子長軸が光の進路PSと平行な場合、光の進路PSに垂直なxy面内で屈折率の差が生じないので、液晶セルCE中を伝搬する常光と異常光の間に位相差が生じず、直線偏光L1は液晶セルCEを透過すると直線偏光のまま伝搬する。偏光板Bの偏光軸PBを偏光板Aの偏光軸PAと直交する様に設定すると(以下、この設定状態をクロスニコルと呼ぶ場合がある)液晶セルCEを通過した光L2は偏光板Bを透過することができず黒色表示(暗状態)となる。

【0004】(B)は、液晶セルCEに光L0が斜めに入射した場合の光の偏光状態を示している。自然光L0が斜めに入射した場合、偏光板Aを通過した光L1はほぼ直線偏光になる。ただし、実際には偏光板Aの特性により若干楕円偏光になる。液晶セルCE中の液晶分子LCの分子長軸が光の進路PSと角度を成すので、光の進路PSに垂直な面内で屈折率の差が生じ、液晶セルCEを透過した光L2は楕円偏光となって偏光板Bに達し、一部の光が偏光板Bを透過してしまう。この様な斜方入射における光の透過は、液晶表示装置のコントラストの低下を招き、好ましくない。

【0005】この様な斜方入射におけるコントラストの低下を防ぎ、視角特性を改善する為には、(C)に示す様に、例えば偏光板Bと液晶セルCEとの間に、光軸が液晶セルCEの法線方向(z軸)に向いた負の一軸性位相差板RFを配置する。この位相差板RFは光軸に対して光が入射する角度が大きくなる程大きい位相差を示す複屈折材料である。この様な構成の液晶表示装置においては、斜方入射し液晶セルCEを透過して楕円偏光となった光L2は、位相差板RFを透過する時の位相遅延作用によって、楕円偏光が元の直線偏光に変換され、偏光

(3)

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板Bで完全に遮断される。一軸性の位相差板RFは負の屈折率異方性を有し、面方向屈折率に対して厚み方向屈折率が小さい。一方、液晶は正の一軸光学異方性を有し、面方向屈折率に対して厚み方向屈折率が高い。位相差板の屈折率差と厚みの積を、液晶の屈折率差と厚みの積に等しく設定することで、液晶の視角依存性を補償する。しかし、従来の位相差板は、偏光板の視角特性まで考慮していない為、表示装置全体として見た場合、補償機能は充分ではなかった。

【0006】

【課題を解決する為の手段】上述した従来の技術の課題を解決する為以下を手段を講じた。即ち、本発明に係る液晶表示装置は基本的な構成として、所定の間隙を介して互いに接合し且つ少くとも片側に電極が形成された一対の基板と、該間隙に保持され該電極に印加された電圧に応じて光学特性が変化する液晶層と、各基板に接合する偏光板と、該偏光板と該液晶層との間に介在しその光学特性の視角依存性を補償する少くとも一枚の位相差板とを備えている。前記液晶層は該基板に垂直な厚み方向に配向制御された負の誘電異方性を有する液晶材料からなる。特徴事項として、前記位相差板は該基板に平行な面方向の光軸及びこれと直交する厚み方向の光軸を有する二軸性の複屈折材料からなる。好ましくは、前記複屈折材料は、面方向で最大となる方位の屈折率を $n_x$ とし、これと直交する方位の屈折率を $n_y$ とし、厚み方向の屈折率を $n_z$ とすると、 $n_x$ の方位が隣接する偏光板の吸収軸と直交している。又好ましくは、前記複屈折材料は、位相差板の厚みを $d_f$ とすると、 $0 < (n_x - n_y) \cdot d_f < 150 \text{ nm}$ の関係を満たす。更に、前記複屈折材料は、位相差板の厚みを $d_f$ とし、液晶層の厚みを $d_{LC}$ とし、厚み方向に沿った液晶層の屈折率異方性を $\Delta n$ とすると、 $\{(n_x + n_y) / 2 - n_z\} \cdot d_f$ の値が $\Delta n \cdot d_{LC}$ の値に応じて設定されている。

【0007】本発明によれば、二軸性の複屈折材料を用いて位相差板を構成しており、基板に平行な面方向の光軸及びこれと直交する厚み方向の光軸を有している。厚み方向に複屈折性を有する液晶層の視角依存性を位相差板の厚み方向の複屈折性により補償する。一方、偏光板の視角依存性については、位相差板の面方向の複屈折性を利用して補償を行う。即ち、位相差板の面方向の複屈折を利用して、入射光の振動方向を偏光板の吸収軸に合わせ込む様にする。以上の構成により、本位相差板は液晶層及び偏光板の視角依存性を同時に補償することが可能となり、液晶表示装置全体の視角特性を顕著に改善できる。

【0008】

【発明の実施の形態】以下図面を参照して本発明の実施の形態を詳細に説明する。図1の(A)に示す様に、本液晶表示装置は所定の間隙を介して互いに接合した一対の基板1、2を用いて組み立てられている。各基板1、

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2は例えばガラスなどからなる。上側の基板1の内表面には電極3が形成されており、下側の基板2の内表面にも電極4が形成されている。両基板1、2の間隙には液晶層5が保持されている。液晶層5は上下の電極3、4に印加された電圧に応じて光学特性が変化し、入射光の透過率を制御する。上側の基板1に接合して上側の偏光板6が配されている。又、下側の基板2に接合して下側の偏光板7が配されている。更に、上側の偏光板6と液晶層5との間に上側の位相差板8が介在している。同様に、下側の偏光板7と液晶層5との間に別の位相差板9が介在している。本実施形態では、上下2枚の位相差板8、9を用いているが、本発明はこれに限られるものではなく、少くとも1枚の位相差板を用いればよい。

【0009】液晶層5は上下の基板1、2に垂直な厚み方向に配向制御された負の誘電異方性を有する材料からなり、電圧印加に応じて図6に示した様な挙動を呈する。即ち、液晶層5は負の誘電異方性及び正の屈折率異方性を有するネマティック液晶を主体とし、これにカイラル材料を添加したものである。電圧無印加状態ではネマティック液晶は基板1、2に対して垂直配向している。電圧印加状態では水平配向に移行し、添加されたカイラル材料の影響により $90^\circ$ ねじれ配向になる。なお、ネマティック液晶分子が垂直配向から水平配向に移行する際、傾斜方位を規制する為、上下の基板1、2の内表面はあらかじめラビング処理が施されている。ラビング処理に代えて他の配向制御方法を採用してもよい。このラビング処理により、ネマティック液晶分子にはラビング方向に沿って例えば $5^\circ$ 程度のプレチルト角が付されている。プレチルト角は基板の法線に対する液晶分子の長軸の傾斜角を意味している。

【0010】本発明の特徴事項として、各位相差板8、9は基板1、2に平行な面方向の光軸及びこれと直交する厚み方向の光軸を有する二軸性の複屈折材料からなる。以下、(B)を参照して、位相差板の光軸、ラビング方向及び偏光板の吸収軸の関係を説明する。(B)は本液晶表示装置の画面を上から見た平面図であり、 $0^\circ$ 及び $180^\circ$ の方位を画面の右左方向に取ってある。複屈折材料は、面方向で最大となる方位の屈折率を $n_x$ とし、これと直交する方位の屈折率を $n_y$ とし、厚み方向の屈折率を $n_z$ とすると、 $n_x$ の方位が隣接する偏光板の吸収軸と直交している。具体的には、上側偏光板6の吸収軸方向と上側の二軸性位相差板8の $n_x$ 方位とが互いに直交している。同様に、下側の偏光板7の吸収軸方向と下側の二軸性位相差板9の $n_x$ 方位とが互いに直交している。この様に設定することで、斜め方向から入射した光の振動方向を偏光板の吸収軸に合わせ込むことが可能になる。なお、上側基板1のラビング方向は上側の偏光板6の吸収軸方向と一致している。又、下側の基板2のラビング方向と下側の偏光板7の吸収軸方向も互いに一致している。そして、上側偏光板6の吸収軸と下側

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偏光板7の吸収軸は互いに直交しており、いわゆるクロスニコル配置となっている。なお、位相差板の面方向の複屈折性を利用して偏光板の視角依存性を改善する為には、前記複屈折材料は位相差板の厚みを $d_f$ とすると、 $0 < (n_x - n_y) \cdot d_f < 150 \text{ nm}$ の関係を満たすことが好ましい。これはシミュレーションの結果であり、最適値は60 nm程度である。

【0011】本発明に係る位相差板8、9は偏光板6、7の視角依存性を補償するとともに、液晶層5の視角依存性も同時に補償している。即ち、各位相差板8、9の厚み方向の複屈折を利用して、液晶層5の厚み方向の複屈折を打ち消す様にしている。この場合、前記複屈折材料は位相差板の厚みを $d_f$ とし、液晶層の厚みを $d_{LC}$ とし、厚み方向に沿った液晶層の屈折率異方性を $\Delta n$ とすると、 $\{(n_x + n_y) / 2 - n_z\} \cdot d_f$ の値が $\Delta n \cdot d_{LC}$ の値に応じて設定される。

【0012】以下、上述した各パラメータに具体的な数値を与えて実施例を説明する。液晶層5の $\Delta n \cdot d_{LC}$ の値は420 nmである。一方、二軸性の各位相差板8、9の $n_x$ は1.58839であり、 $n_y$ は1.58797であり、 $n_z$ は1.58705である。各位相差板8、9の厚み $d_f$ は142  $\mu\text{m}$ である。更に、上下の各偏光板6、7に含まれる保護膜の $n_x$ は1.59082であり、 $n_y$ は同じく1.59082であり、 $n_z$ は1.5902である。この保護膜の厚みは80  $\mu\text{m}$ である。以上の $\Delta n$ 、 $n_x$ 、 $n_y$ 、 $n_z$ の値は波長550 nmの入射光に対して測定したものである。各位相差板8、9に着目すると、 $\{(n_x + n_y) / 2 - n_z\} \cdot d_f = 160 \text{ nm}$ となる。この値は、1枚の位相差板の厚み方向におけるリターデーションを表わしている。又、各偏光板6、7に含まれる保護膜の厚み方向のリターデーションは $(1.59082 - 1.5902) \times 80 \mu\text{m} = 50 \text{ nm}$ である。本実施例では、上下に2枚の位相差板8、9を用い、偏光板6、7も上下で2枚用いられている。従って、上述した厚み方向のリターデーションの総和は $160 \text{ nm} \times 2 + 50 \text{ nm} \times 2 = 420 \text{ nm}$ である。この値は液晶層5のリターデーション $\Delta n \cdot d_{LC}$ の値420 nmと一致する。これにより、液晶層5の複屈折性を位相差板8、9で打ち消すことが可能になる。各位相差板8、9のリターデーションの値を設定する際、偏光板6、7に含まれる保護膜のリターデーションの値を考慮して、両者の合計が液晶層5のリターデーションと概ね一致する様にすればよい。一方、各位相差板8、9の面方向のリターデーションの値は、本実施例の場合 $(n_x - n_y) \cdot d_f = 60 \text{ nm}$ に設定している。一般に、各位相差板8、9の面方向のリターデーションは150 nm未満で適切に設定すればよい。150 nmを超えると、位相差板の面方向の複屈折が強すぎる様になり、逆に液晶表示装置の視角特性に悪影響を与える恐れがある。

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【0013】図2は、液晶表示装置の視角特性を示すグラフである。表示装置の画面の面方位を右方向に $0^\circ$ とし、左方向に $180^\circ$ と決めている。 $0^\circ$ から $360^\circ$ まで方位を変え、且つ画面の法線に対して斜め方向から測定した場合の等コントラスト曲線を表わしている。内側の等コントラスト曲線はコントラスト比50に対応しており、外側のコントラスト曲線はコントラスト比10に対応している。なお、コントラスト比は印加電圧がOFFの時の透過率と印加電圧がONの時の透過率との比を取ったものである。(A)は本発明に従って二軸性の位相差板を用いた場合の測定結果であり、(B)は従来の一軸性の位相差板を用いた測定結果である。両者を比較すれば明らかな様に、従来に比べ本発明では液晶表示装置の視角特性が大幅に改善されている。即ち、二軸性の位相差板を用いることにより、液晶層の視角依存性ばかりでなく偏光板の視角依存性も同時に改善することが可能である。

【0014】図3は、本発明に係る液晶表示装置の他の実施形態を示す模式図である。基本的には、図1に示した先の実施形態と同様であり、対応する部分には対応する参照番号を付して理解を容易にしている。異なる点は、本実施形態では電圧印加状態で、液晶分子5mはねじれ配向せず、水平配向することである。この為、上側基板1のラビング方向と下側基板2のラビング方向は互いに平行になっている。又、液晶にはカイラル材料が添加されていない。(A)に示す様に、信号電圧の無印加時液晶分子5mが垂直配向する一方、信号電圧の印加時水平配向に移行して入射光の変調を行う。上側の偏光板6と下側の偏光板7はクロスニコルに配置されている。(A)の左側に示す様に、電圧無印加状態では液晶分子5mは垂直配向しており、入射偏光は何ら変調を受けずに出射偏光としてそのまま出射する。従って、クロスニコルの状態では電圧無印加時(OFF時)表示は黒色を呈する。一方、(A)の右側に示す様に、電圧印加時では液晶分子5mは紙面と平行な方位に沿って水平配向に移行する。この液晶分子5mの配向状態は一軸性の複屈折を呈し、偏光板6を通過した入射偏光は水平配向した液晶分子5mにより $90^\circ$ 偏光方向が回転して出射偏光となる。この為、クロスニコル配置した下側の偏光板7を出射偏光が通過可能となり、電圧印加状態(ON状態)では表示は白色となる。換言すると、水平配向した液晶はその厚みを適切に設定することで、二分の一波長板として機能する。液晶セルに電圧を印加すると、液晶の誘電異方性により、液晶分子配列が変化し、その結果セル中の複屈折率が変化する。液晶セルを2枚の偏光板6、7中に置くと、この複屈折率の変化が光透過率の変化として現れ、これをECB効果という。この効果を利用して表示を行う方式をECBモードといい、初期配向の違いによりDAP型、ホモジニアス型、HAN型に分類される。本実施形態は、特にこの内DAP型を採用し

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ている。即ち、液晶分子5mの分子軸（液晶ディレクタ）が基板に対して垂直となっているホメオトロピック配向セルを用いるものをDAP型といい、誘電異方性が負のネマティック液晶を用いる。このDAP型において、表示のコントラストを高くする為には、電圧印加時に分子の傾斜を一方に揃えることが重要であり、この為には液晶ディレクタが基板からやや傾いた初期配向（プレチルト）を取らせる。本実施形態では、このプレチルト角は $5^\circ$ に設定している。

【0015】本実施形態でも、液晶セルの上下に配された各位相差板8、9は二軸性であり、先の実施形態と同様である。（B）に示す様に上偏光板6の吸収軸方向と上側の二軸性位相差板8のnx方位とは互いに直交している。又、下偏光板7の吸収軸方向と下側の二軸性位相差板9のnx方位も互いに直交している。前述した様に、上偏光板6の吸収軸方向と下偏光板7の吸収軸方向とは互いに直交しており、クロスニコルとなっている。又、下側ラビング方向と上側ラビング方向は互いに平行である。これらのラビング方向は、偏光板の吸収軸方向と $45^\circ$ の角度を成している。

【0016】図4の（A）は図3に示した実施形態の等コントラスト曲線を示すグラフである。（B）は、比較の為、二軸性位相差板に代えて一軸性位相差板を用いた場合の等コントラスト曲線を示す。（A）及び（B）を比較すれば明らかな様に、本実施形態でも二軸性の位相差板を用いることで、液晶表示装置全体としての視角特性を改善することが可能になる。

【0017】位相差板の複屈折性を利用した視野角の改善技術は、他の方式を利用した視野角改善技術と組み合わせることができる。例えば、マトリックス状に配列した画素を有する液晶表示装置において、各画素内で二分割又は四分割した配向制御を行うことで視野角を改善できる。本発明は、この様な配向分割法による視野角改善技術と組み合わせることができる。又、指向性のバックライトと光拡散板との組み合わせを用いた視野角改善技術と組み合わせることもできる。この実施形態を図5に示す。なお、この実施形態において、図1に示した実施形態と対応する部分には対応する参照番号を付して理解を容易にしている。（A）に示す様に、本液晶表示装置は透過型のパネル0と指向性バックライト20と光拡散板10とから構成されている。パネル0は一对のガラス基板を互いに貼着した構成を有し、両者の間隙に液晶が封入されている。上側基板の前面には偏光板6と二軸性の位相差板8が配置されている。下側ガラス基板の後面にも別の偏光板7及び二軸性の位相差板9が配置している。これらのガラス基板は例えば1.53程度の屈折率を有している。指向性バックライト20はパネル0の後面側に配置され平行に近い照明光をパネル0に入射する。本例では、バックライト20は光源21とプリズムシート22とからなる。光源21は平面型の蛍光管など

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からなり無指向性の光を放射する。プリズムシート22は光源21から放射した無指向性の光を屈折させ、ほぼ平行光にコリメートする。

【0018】光拡散板10は前面側に配置され、パネル0を透過した照明光を拡散射出する。光拡散板10はパネル0の前面と位相差板8との間に敷き詰められた透明な微粒子10aからなる。この微粒子10aの間隙は透明な充填剤10bにより埋められている。微粒子10aはパネル0の前面を構成するガラス基板とは異なる屈折率を有する一方、充填剤10bはガラス基板に近い屈折率を有している。例えば、この微粒子10aは透明なマイクロビーズからなり、平均粒径が $30\mu\text{m}$ 程度で、屈折率は1.93である。これは、ガラス基板の屈折率1.53と大きく相違しており、優れた光拡散性を備えている。なお、ガラス基板の板厚は例えば1.1mm程度である。一方、透明な充填剤10bは例えば紫外線硬化型の樹脂からなり、その屈折率は1.55であり、ほぼガラス基板の屈折率と等しい。指向性バックライト20から射出した透明光はパネル0を通過した後、微粒子10aにより散乱した形で射出する。微粒子10aの屈折率が大きい程拡散が強く起こり視野角が広がる。

【0019】（B）は、（A）に示したパネル0の一例を示す模式的な断面図である。このパネルは液晶セル111とブラズマセル112と両者の間に介在する誘電体シートからなる共通の中間板113とを積層したフラット構造を有する。液晶セル111は前面側のガラス基板114を用いて構成されており、その内側主面には透明導電膜からなる複数本の信号電極115が互いに平行に形成されている。ガラス基板114はスペーサ116を用いて所定の間隙を介し中間板113に接着されている。間隙内には液晶117が充填されている。一方、ブラズマセル112は後面側のガラス基板118を用いて構成されている。ガラス基板118の内側主面上には信号電極115に直交する複数のプラズマ電極119が形成されており、交互にアノード120及びカソード121として対を成す。ガラス基板118の内表面には各電極対を区画化する為にストライプ状の隔壁122が形成されている。隔壁122の頂部は中間板113に当接している。ガラス基板118はフリットシール123を用いて中間板113に接合されている。両者の間には気密封止されたプラズマ室124が形成される。このプラズマ室124は隔壁122によって分割されており個々に走査単位となる放電チャネルを構成する。この気密なプラズマ室124の内部にはイオン化可能なガスが封入されている。ガス種は例えばヘリウム、ネオン、アルゴンあるいはこれらの混合気体を選ぶことができる。各走査単位を構成する放電チャネルと駆動単位を構成する信号電極115とは互いに直交しておりその交差部にマトリックス状の画素が規定される。

【0020】係る構成を有するパネルにおいては、プラ



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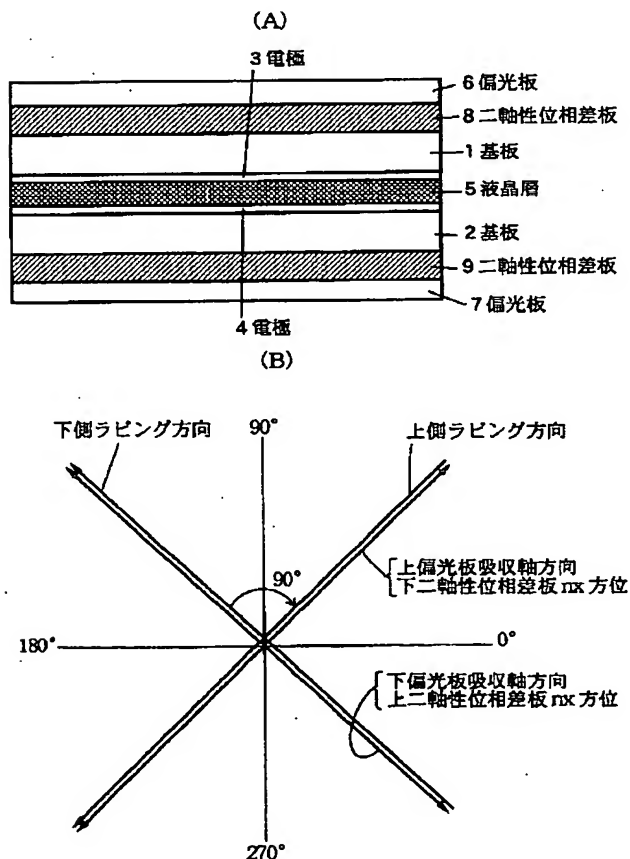
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ズマ放電が行われる放電チャンネルを線順次で切り換え走査するとともに、この走査に同期して液晶セル111側の信号電極115に画像信号を印加することにより表示駆動が行われる。放電チャンネルにプラズマ放電が発生すると内部はほぼ一様にアノード電位になり一ライン毎の画素選択が行われる。即ち、放電チャンネルはサンプリングスイッチとして機能する。プラズマサンプリングスイッチが導通した状態で各画素に画像信号が印加されると、サンプリングが行われ画素の点灯もしくは消灯が制御できる。プラズマサンプリングスイッチが非導通状態になった後にも画像信号はそのまま画素内に保持される。

【0021】

【発明の効果】以上説明したように、本発明によれば、基板に平行な面方向の光軸及びこれと直交する厚み方向の光軸を有する二軸性の複屈折材料を用いて液晶の視角依存性と偏光板の視角依存性を同時に補償している。係る構成により、液晶表示装置の視角特性を改善することが可能になり、コントラストが高く且つ視角範囲が広い表示画面を得ることができる。

【図1】



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【図面の簡単な説明】

【図1】本発明に係る液晶表示装置の実施形態を示す模式図である。

【図2】液晶表示装置の等コントラスト曲線を示すグラフである。

【図3】本発明に係る液晶表示装置の他の実施形態を示す模式図である。

【図4】液晶表示装置の等コントラスト曲線を示すグラフである。

【図5】本発明に係る液晶表示装置の別の実施形態を示す模式的な断面図である。

【図6】従来の液晶表示装置の一例を示す模式図である。

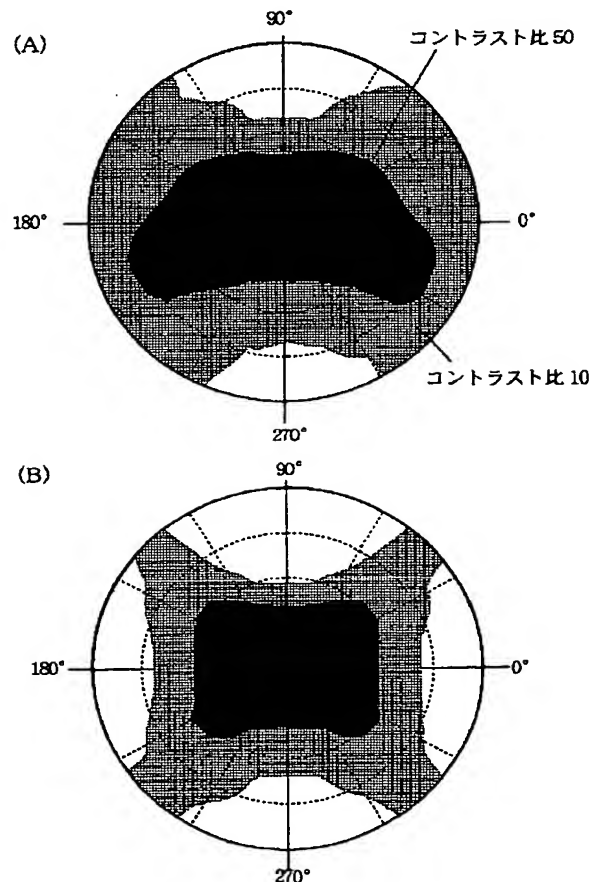
【図7】従来の液晶表示装置に用いられる位相差板の作用を示す模式図である。

【符号の説明】

1・・・基板、2・・・基板、3・・・電極、4・・・電極、5・・・液晶層、6・・・偏光板、7・・・偏光板、8・・・二軸性位相差板、9・・・二軸性位相差板

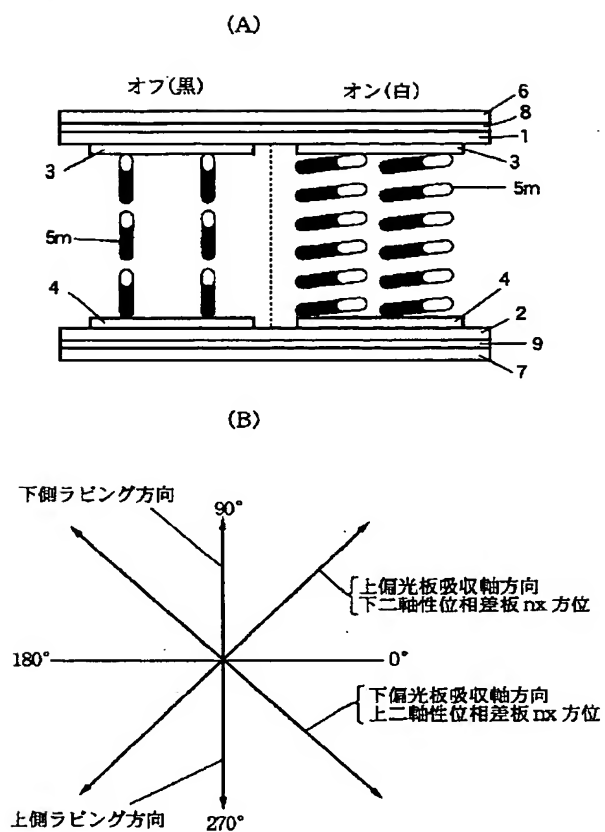
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【図2】

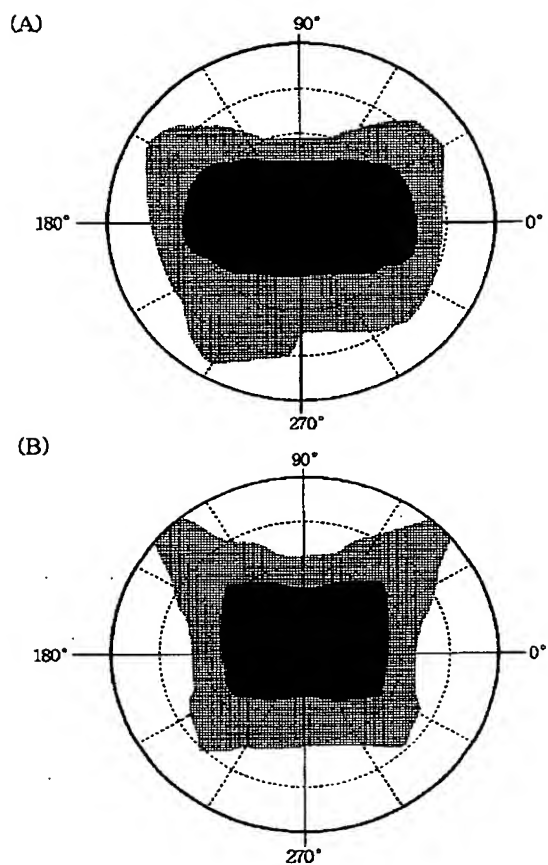


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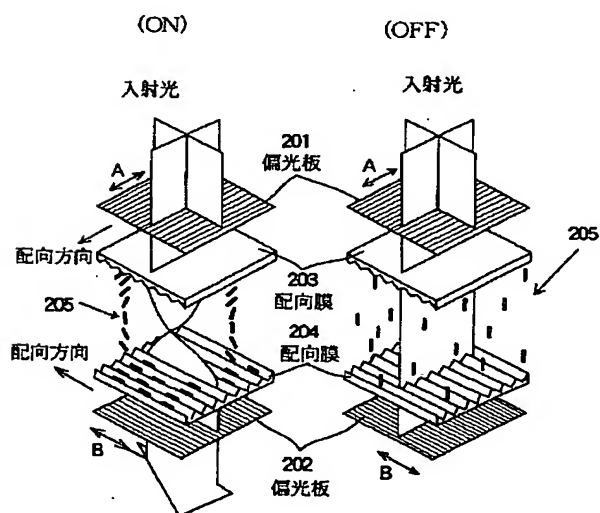
【図3】



【図4】

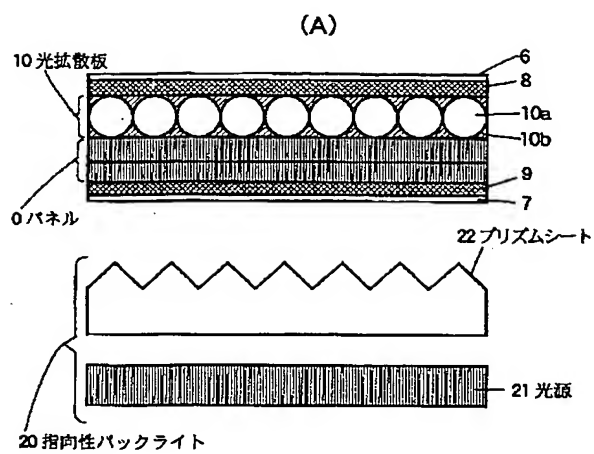


【図6】

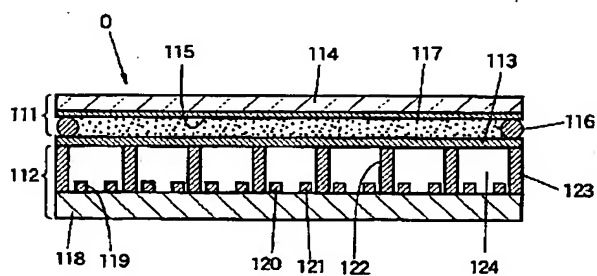


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【図5】

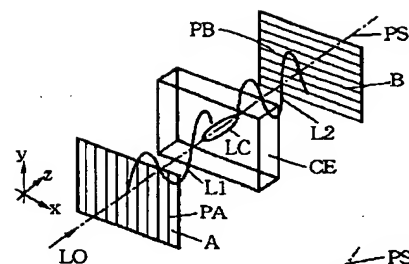


(B)

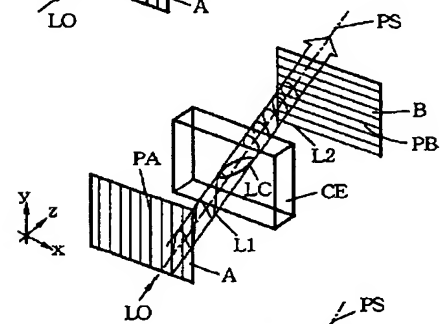


【図7】

(A)



(B)



(C)

